PAT. APPL.
IN-34 69485

NASA CASE NO. LAR 14547-1

PRINT FIG. 1 P. 12

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LaRC

(NASA-Case-LAR-14547-1) PASSIVE CONTROL OF PRESSURE LOADS USING POROSITY Patent Application (NASA) 12 p CSCL 20D

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NASA Case No. LAR 14547-1

AWARDS ABSTRACT

PASSIVE CONTROL OF PRESSURE LOADS USING POROSITY

Pressure loading of a member is caused by movement of a fluid and/or the member relative to one another. Mechanical devices such as strakes and flaps are often used on vehicles to effectively alter the exterior surface of the vehicular member to achieve a desired reaction to loading. Also various air loading displacement systems are used which suck air from a high pressure area and/or forcibly exit air at a low pressure area to compensate for load induced pressure gradients. These mechanical devices and displacement systems are relatively complicated, have significant energy requirements, add weight to the vehicle, consume often critical space, and are often ineffective over a wide range of angles of attack and lift conditions.

A device for controlling pressure loading of a member is provided which consists of a porous skin mounted over the solid surface of the member and separated from the solid surface by a plenum. Fluid from an area exerting high pressure on the member may enter the plenum through the porous surface and exit into an area exerting a lower pressure on the member, thus controlling pressure loading of the member.

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PASSIVE CONTROL OF PRESSURE LOADS USING POROSITY

Origin of the Invention

The invention described herein was made by employees of the United States Government and may be used by and for the Government for governmental purposes without the payment of any royalties thereon or therefor.

Background of the Invention

1. Technical Field of the Invention

The present invention relates generally to controlling the pressure load on various members, and more particularly to the passive control of pressure loads using porosity.

2. Discussion of the Related Art

Pressure loading of a member can be caused by movement of the fluid and/or the member relative to one another. For example, many portions of an aircraft such as its forebody, canopy, fuselage, wings and tails are subjected to high air loads during flight. These air loads can vary significantly with model attitude and forward flight speed. Of particular concern for high performance military aircraft is that, depending on the geometry of the aircraft and its angle of attack, it may experience a large side force which results in a yawing moment which may be difficult to control. At low angles of attack the flow field is usually symmetric. As the angle of attack increases, two counterrotating, stationary vortices form on the leeward side of the forebody of the aircraft. At higher angles of attack, the vortices become asymmetric with one exerting

greater pressure on the aircraft than the other thus resulting in a net side force. The resultant force on the vehicle can be extreme and create an unsafe condition or significantly reduce the flight envelope of the aircraft.

Likewise, many helicopter components such as the tailboom, helicopter body, rotor hub and the rotor itself bear high loads. Land based vehicles such as cars, trucks, vans and especially tractor trailers often encounter huge loads due to inadequate front, top and rear designs. Also buildings, in particular roofs, are exposed to loads from wind conditions which can cause undue strain and even catastrophic failure.

Numerous solutions have been proposed for controlling pressure load which are usually member specific. Initial design of the exterior of the member is an important consideration but is unable to adapt to changing loading conditions. Mechanical devices such as strakes and flaps are often used on vehicles to effectively alter the exterior surface of the vehicular member to achieve a desired reaction to loading. Also various air loading displacement systems are used which suck air from a high pressure area and/or forcibly exit air at a low pressure area to compensate for load induced pressure gradients. These mechanical devices and displacement systems are relatively complicated, have significant energy requirements, add weight to the vehicle, consume often critical space, and are often ineffective over a wide range of angles of attack and lift conditions. Most attempts to reduce air loading on buildings involve initial exterior design as well as flexible internal structure which yields slightly to wind loads.

It is accordingly an object of the present invention to control pressure loading on members.

It is another object of the present invention to control pressure loading over a wide range of member attitude and free stream flow conditions.

It is another object of the present invention to achieve the foregoing objects with a passive device.

It is another object of the present invention to achieve the foregoing objects with a simple control device using minimal energy.

It is a further object of the present invention to achieve the foregoing objects with minimal spatial and mass requirements.

It is yet another object of the present invention to accomplish the foregoing objects in a simple manner.

Additional objects and advantages of the present invention are apparent from the drawings and specification which follow.

Summary of the Invention

According to the present invention, the foregoing and additional objects are obtained by providing a pressure equalization device for use on a member exposed to a fluid load. This device consists of a porous outer skin, a solid inner surface with a plenum created between the two such that the fluid may pass through the porous material into the plenum and back through the porous material to equalize the external pressures on the member. The depth of the plenum between the porous skin and solid surface should be no more than about two times the thickness of the boundary layer formed on the surface of the member as a result of the member being in a fluid flow. Ideally the porous outer skin has a surface porosity of about 10 to 20% and can be made from a porous material or from a solid material which has been perforated. If the latter method is used, the perforations should be no more than about one boundary layer thickness in diameter. The thickness of the porous outer skin should be no less than the diameter of the perforations.

Brief Description of the Drawings

Fig. 1 is a perspective view showing a porous skin mounted outside of a solid surface;

Fig. 2 is a cross sectional view taken along line II-II;

Fig. 3 shows the vortices formed without a porous skin; and

Fig. 4 shows the vortices formed with a porous skin.

Detailed Description of the Invention

Figure 1 shows a forebody 12 of an aircraft. A portion of the forebody 12 is covered with a porous skin 14. The required thickness is a function of the pressure load and the required response time for pressure equalization, about one boundary layer thickness. The porosity of the porous skin 14 is optimally between 10 and 20%. The porous skin 14 may be made from a porous material, such as sintered metal, or from a solid material, such as steel or fiberglass, which has been perforated, however these perforations should be no more than about one boundary layer thickness in diameter in order to minimize the disturbance of the external flow field.

Figure 2 shows the porous skin 14 mounted outside of the solid surface 16 of the aircraft, forming a plenum 18 between the porous skin 14 and the solid surface 16. The porous skin 14 must be mounted over the plenum 18 such that there is minimal blockage in both the longitudinal and circumferential directions. The depth of plenum 18 should be about twice the thickness of the boundary layer formed on the surface of the aircraft in flight.

In flight conditions where asymmetric vortices 20,22 and a boundary layer 28 are formed on the forebody 12 of the aircraft as shown in figure 3, one vortex 22 is stronger and exerts a higher pressure on the aircraft than the other vortex 20. When the solid surface 16 is covered with a porous skin 14, air from the high pressure area formed by the stronger vortex 22 passes through the porous skin 14 into the plenum 18, flows through the plenum 18 to the area of low pressure formed by the weaker vortex 20 and passes back through the porous skin 14, thus equalizing the uneven pressures. Figure 4 shows the symmetric vortices 24,26 which occur on the forebody 16 when the porous skin

14 is mounted over the solid surface 16, as well as the modified boundary layer 28.

This invention may be used to equalize pressures on any object in a fluid flow including but not limited to aircraft, rotorcraft, cars, trucks, ships, submarines, buildings, pipes and ducts.

What is claimed is:

PASSIVE CONTROL OF PRESSURE LOADS USING POROSITY

Abstract of the Disclosure

A device for controlling pressure loading of a member caused by a fluid moving past the member or the member moving through a fluid. The device consists of a porous skin mounted over the solid surface of the member and separated from the solid surface by a plenum. Fluid from an area exerting high pressure on the member may enter the plenum through the porous surface and exit into an area exerting a lower pressure on the member, thus controlling pressure loading of the member.

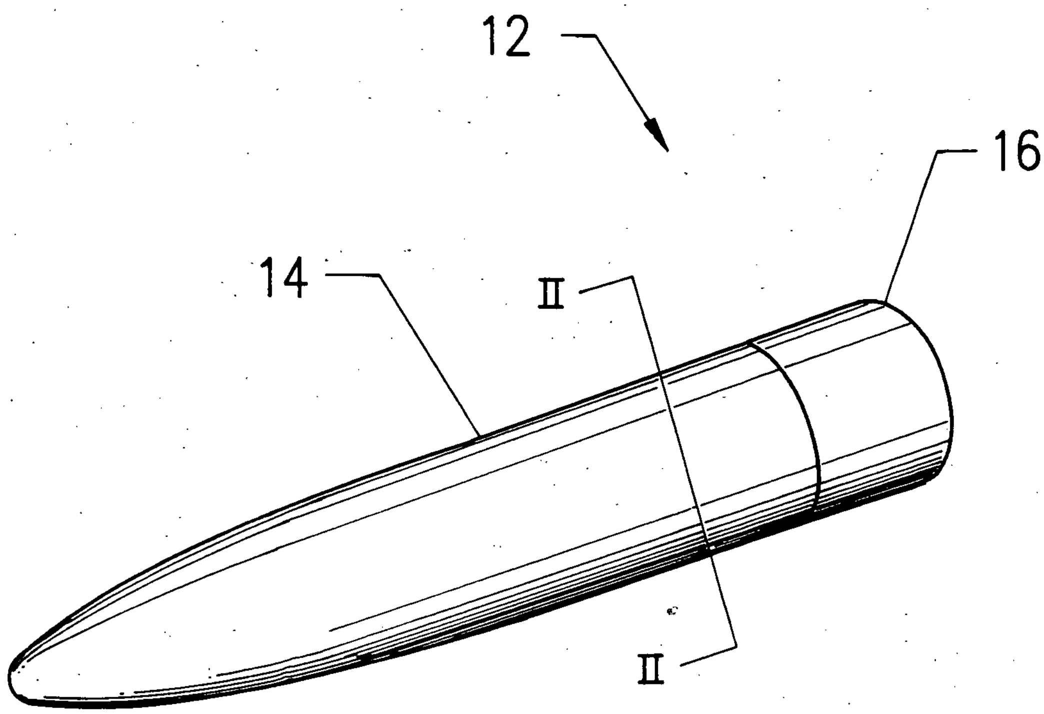

FIG. 1

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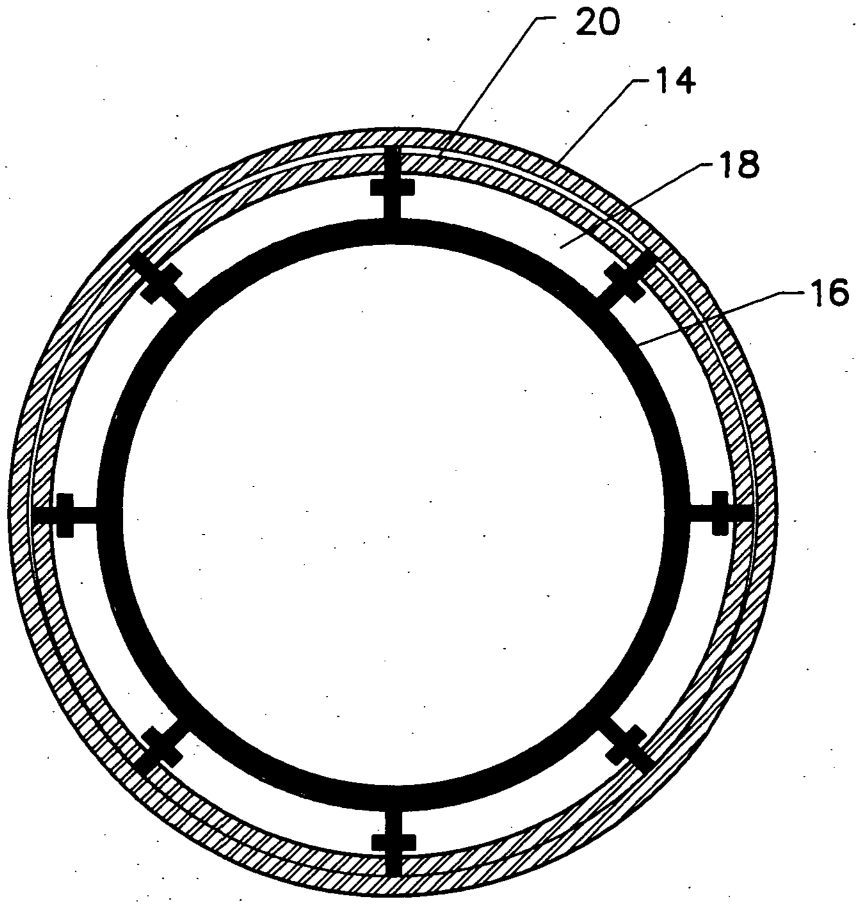

FIG. 2

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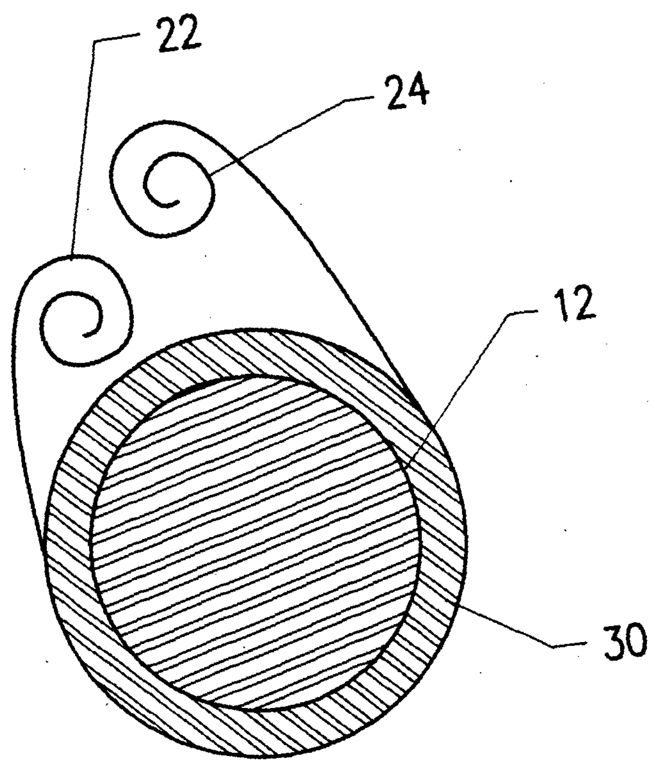

FIG. 3

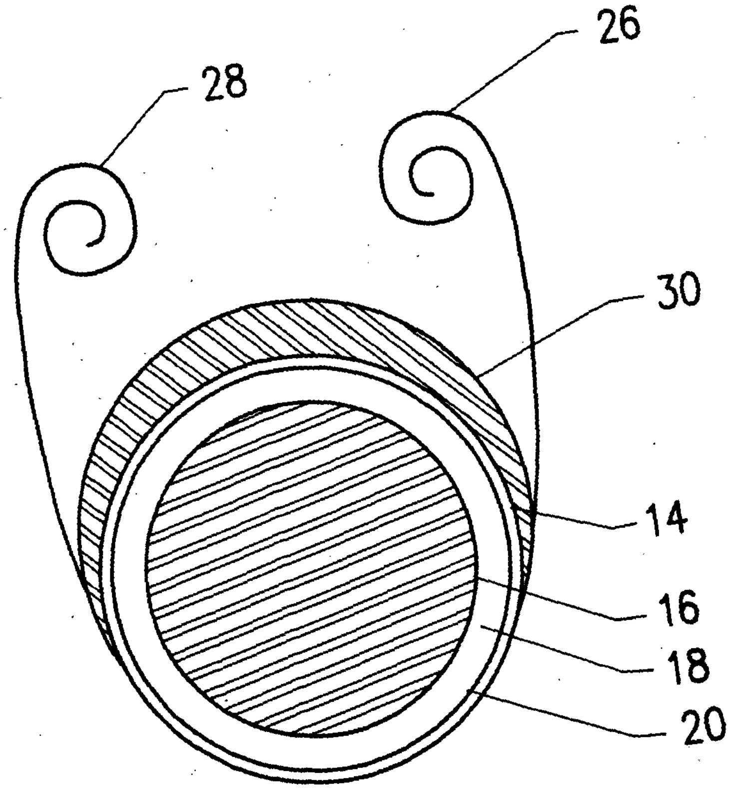

FIG. 4

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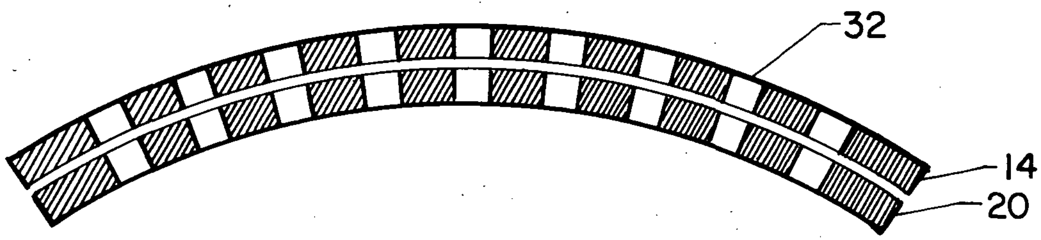

FIG. 5a

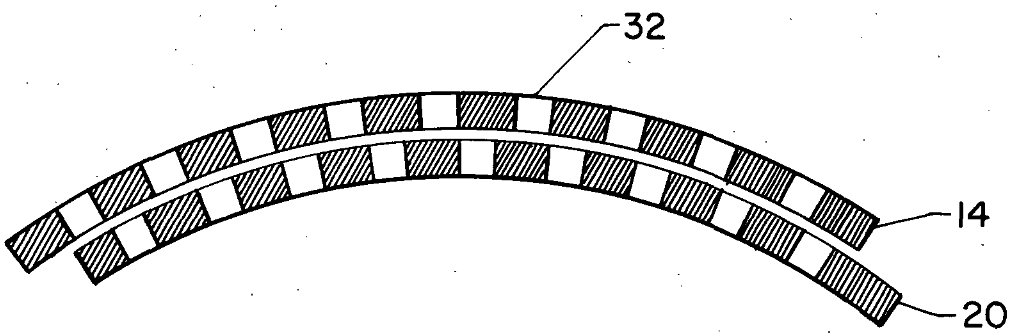

FIG. 5b

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